

# APPENDIX - Computer Program Code

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# Call external software to process data (clean, remove rayleigh, scale)
print "Calling external processing software.\n";
system ("process_modis") == 0 or die "Problem with process_modis: $!";

##SNIPPET FROM process_modis_color.f90 PERTAINING TO DE**
#! 1) Atmospheric Correction (snippet)
# airmass = 1.0/mu_sun + 1.0/mu_sat
# trans_sat = exp(-1.0*ray_taus(i)/mu_sat)
# trans_sun = exp(-1.0*ray_taus(i)/mu_sun)
# tro = proc_chandat*pi/( F_sun_adj(i) * mu_sun * exp(-1.0*airmass*uoaz*aoz(i))
# )
# trayu = ( (2.0/3.0 + mu_sat)+(2.0/3.0 - mu_sat)*trans_sat) / &
# ( 4.0/3.0 + ray_taus(i) )
# trayd = ( (2.0/3.0 + mu_sun)+(2.0/3.0 - mu_sun)*trans_sun) / &
# ( 4.0/3.0 + ray_taus(i) )
# tro = (tro-ray_ref)/( trayu*trayd*exp(-1.0*airmass*(ao2(i) + awv(i))) )
# proc_chandat = tro/(1.0+raysa(i)*tro) !units of reflectance [0-1]
#! 2) Truncate negative numbers to 0, if they occur
#! Truncate numbers greater than unity to unity, if they occur
# WHERE (proc_chandat < 0.0223) proc_chandat = 0.0223
# WHERE (proc_chandat > 1.0) proc_chandat = 1.0
#! 3) Scale the processed data if applicable
# print *, "Scaling the data by log_10"
# proc_chandat = LOG10(proc_chandat)
#! 4) Dust Enhancement
# print *, "Creating dust enhancement"
# WHERE ( ((chan03_dat+chan02_dat) > 0.0) .AND. (chan02_dat > 0.0223) )
# dust_enhance = (chan02_dat-cha03_dat)/(chan02_dat+chan03_dat)
# ELSEWHERE
# dust_enhance = -0.40
# ENDWHERE
#! 5) Truncate between desired values
# WHERE (dust_enhance < -0.40) dust_enhance = -0.40
# WHERE (dust_enhance > 0.15) dust_enhance = 0.15
###END SNIPPET###

#-----
# Dust Enhancement
#-----
if ($have_ir) {

print "Creating a \"dust enhanced\" image: ${OUTNAME}.dust1KM.$SECTOR.x.tiff\n";
###
# Water component
###
print "Doing ocean component...\n";

$min_blue_scl = -1.45;
$max_blue_scl = 0.0;
$min_green_scl = -1.45;
$max_green_scl = 0.0;
$min_de_scl = -0.40;
$max_de_scl = 0.15;

system ("emathp expr_vars='ref_469 ref_555 DE' num_exprs=3 ".
        "y1_expr='land ? $min_blue_scl : x1' ".
        "y2_expr='land ? $min_green_scl : x2' ").
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"y3_expr='land ? $min_de_scl : x3' ".
"use_degrees= poly_size=100 box_sides='1 1' ".
"min_good='1' save_exprs='1 2 3' var_names='Blue_ocean Green_ocean
Red_ocean' ".
"var_units= var_types='float float float' scale_offsets= scale_factors=
".
"reflec_assem_$pid tmp_ocean_$pid") == 0 or die "Problem with emathp:
$!";

system ("imscale include_vars='Blue_ocean' image_colors=250 bg_color=250
bad_color=0 ".
"over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
"zoom_factor=1 real_resample=no est_range=no min_value=$min_blue_scl
max_value=$max_blue_scl invert_scale=no ".
"north_up=yes tmp_ocean_$pid tmp_blue_$pid") == 0 or die
"Problem occurred during imscale of blue ocean-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Blue_ocean image_colors=250
color_palette=black-white ".
"draw_indexes= draw_names= tmp_blue_$pid blue_ocean.tiff_$pid") == 0 or
die
"Problem occurred during expim of blue_ocean.tiff_$pid creation: $!";

system ("imscale include_vars='Green_ocean' image_colors=250 bg_color=250
bad_color=0 ".
"over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
"zoom_factor=1 real_resample=no est_range=no min_value=$min_green_scl
max_value=$max_green_scl invert_scale=no ".
"north_up=yes tmp_ocean_$pid tmp_green_$pid") == 0 or die
"Problem occurred during imscale of green ocean-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Green_ocean image_colors=250
color_palette=black-white ".
"draw_indexes= draw_names= tmp_green_$pid green_ocean.tiff_$pid") == 0
or die
"Problem occurred during expim of green_ocean.tiff_$pid creation: $!";

system ("imscale include_vars='Red_ocean' image_colors=250 bg_color=250
bad_color=0 ".
"over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
"zoom_factor=1 real_resample=no est_range=no min_value=$min_de_scl
max_value=$max_de_scl invert_scale=no ".
"north_up=yes tmp_ocean_$pid tmp_de_$pid") == 0 or die
"Problem occurred during imscale of red (DE) ocean-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Red_ocean image_colors=250
color_palette=black-white ".
"draw_indexes= draw_names= tmp_de_$pid red_ocean.tiff_$pid") == 0 or die
"Problem occurred during expim of red_ocean.tiff_$pid creation: $!";

# Make RGB image
system ("tifftopnm red_ocean.tiff_$pid > red_ocean.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";

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system ("tifftopnm green_ocean.tiff_$pid > green_ocean.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";
system ("tifftopnm blue_ocean.tiff_$pid > blue_ocean.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";
system ("ppmtopgm red_ocean.ppm_$pid > red_ocean.pgm_$pid") == 0 or die
"Problem with ppmtopgm call: $!";
system ("ppmtopgm green_ocean.ppm_$pid > green_ocean.pgm_$pid") == 0 or die
"Problem with ppmtopgm call: $!";
system ("ppmtopgm blue_ocean.ppm_$pid > blue_ocean.pgm_$pid") == 0 or die
"Problem with ppmtopgm call: $!";
system ("rgb3toppm red_ocean.pgm_$pid green_ocean.pgm_$pid blue_ocean.pgm_$pid
> tmp_ocean.ppm_$pid") == 0 or die "Problem with rgb3toppm call: $!";
system ("convert ppm:tmp_ocean.ppm_$pid tiff:tmp_ocean_one.tiff_$pid") == 0
or die "Problem occurred during convert of modis dust enhancement
product: $!";

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```
# Sunglint mask
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###
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print "Making sunglint mask for use with dust enhancement imagery...\n";
$min_sunglint = 30.0;
$delta = 0.25;
system ("emathp expr_vars='sunglint ref_853' num_exprs=1 "
"y1_expr='land ? badval :
(x1<($min_sunglint+$delta))&&(x1>($min_sunglint-$delta)) ? "
"100 : (x1<($min_sunglint-$delta)) ? x2 : badval' "
"use_degrees= poly_size=100 box_sides='1 1' "
"min_good='1' save_exprs='1' var_names='glintmask' "
"var_units= var_types='float' scale_offsets= scale_factors= "
"reflec_assem_$pid tmp_glint1_$pid") == 0 or die "Problem with emathp:
$!";

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system ("imscale include_vars='glintmask' image_colors=250 bg_color=250
bad_color=0 "
"over_color=252 under_color=2 max_width=$SAMPLES max_height=$LINES
fixed_size=yes "
"zoom_factor=1 real_resample=no est_range=no min_value=$min_green_scl
max_value=$max_green_scl invert_scale=no "
"north_up=yes tmp_glint1_$pid tmp_glint_$pid") == 0 or die
"Problem occurred during imscale of green ocean-component of dust
enhancement: $!";

```

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system ("expim image_format=tiff image_var=glintmask image_colors=250
color_palette=black-white "
"draw_indexes='252' draw_names='yellow' tmp_glint_$pid
tmp_glint.tiff_$pid") == 0 or die
"Problem occurred during expim of tmp_glint.tiff_$pid creation: $!";

```

```
# Merge Sunglint Mask and Ocean image
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system ("imgmerge background_file=tmp_ocean_one.tiff_$pid
foreground_file=tmp_glint.tiff_$pid clear_color=black "
"output_format=tiff tmp_ocean.tiff_$pid") == 0 or die "Problem with
imgmerge: $!";

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###
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```
# Land component
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###
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print "Doing land component...\n";
####
$min_blue_scl = -1.45;
$max_blue_scl = 0.0;
$min_green_scl = -1.45;
$max_green_scl = 0.0;
$min_red_scl = 1.30;
$max_red_scl = 2.70;
$min_rmb_lnd = -0.10;
$max_rmb_lnd = 0.25;
@stat = `stats include_vars=modis_ch31 printout=no reflec_assem_spid`;
@stat2 = split(/ +/, $stat[4]);
$min_31 = $stat2[3];
$max_31 = $stat2[4];
print "Modis ch31 has min value of $min_31 and max of $max_31\n";
$max_irlnd = $max_31;
if ($max_irlnd < 28.0) {
    $min_irlnd = $max_irlnd-21.0;
} else {
    $min_irlnd = $max_irlnd/4.0;
}
print "...setting min_irlnd = $min_irlnd, max_irlnd = $max_irlnd\n";
# Should make fmf limits dynamic
$min_fmflnd = -2.0;
$max_fmflnd = 2.0;
$min_rmb_ir_diff = -1.5;
$max_rmb_ir_diff = 0.25;
$min_ch26 = 5.0;
####
system ("emathp expr_vars='ref_469 ref_555 ref_645 ref_853 modis_ch26
modis_ch31 modis_ch32' num_exprs=10 ").
    "y1_expr='land && ! bad(x6)? pow(10,x3)-pow(10,x1) : badval' ".
    "y2_expr='land && ! bad(x6)? pow(10,x2)-pow(10,x3) : badval' ".
    "y3_expr='land && ! bad(x6)? y1-y2 : badval' ".
    "y4_expr='land && ! bad(x6)? (x6>$max_irlnd) ? $max_irlnd :
(x6<$min_irlnd) ? $min_irlnd : x6 : badval' ".
    "y5_expr='land && ! bad(x6)? (y4-$min_irlnd)/($max_irlnd-$min_irlnd) :
badval' ".
    "y6_expr='land && ! bad(x6)? ((y3-y5)-
$min_rmb_ir_diff)/($max_rmb_ir_diff-$min_rmb_ir_diff) : badval' ".
    "y7_expr='x7-x6' ".
    "y8_expr='land && ! bad(x6)? (y7>$max_fmflnd) ? $max_fmflnd :
(y7<$min_fmflnd) ? $min_fmflnd : y7 : badval' ".
    "y9_expr='(y8-$min_fmflnd)/($max_fmflnd-$min_fmflnd)' ".
    "y10_expr='land && ! bad(x6)? (x5>$min_ch26) ? 1.0 : 0.0 : badval' ".
    "use_degrees= poly_size=100 box_sides='1 1' ".
    "min_good='1' save_exprs='1 2 3 4 5 6 7 8 9 10' ".
    "var_names='red_blu_diff grn_red_diff y1_y2_diff ir_trunc ir_norm
y3_y5_diff fmf fmf_trunc fmf_norm wv26_norm' ".
    "var_units= var_types='float float float float float float float
float float' scale_offsets= scale_factors= ".
    "reflec_assem_spid rmb_ir_landdiff_spid") == 0 or die "Problem with
emathp: $!";

system ("copyvar include_vars='y3_y5_diff fmf_norm wv26_norm ir_norm'
overwrite_vars=n ").

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    "rmb_ir_landdiff_$pid reflec_assem_$pid") == 0 or die "Problem with
copyvar: $!";

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$min_topo = 3000.0;
$stopo_scale = 3000.0;
system ("emathp expr_vars='ref_469 ref_555 y3_y5_diff fmf_norm wv26_norm
modis_ch03 ir_norm elevation' num_exprs=3 ".
    "y1_expr='land && ! bad(x6) ? x1 : badval' ".
    "y2_expr='land && ! bad(x6) ? x2 : badval' ".
    "y3_expr='land && ! bad(x6) ? (x8>$min_topo) ? x3+x4-x5+(1.0-x7)-
x8/$stopo_scale: x3+x4-x5+(1.0-x7) : badval' ".
    "use_degrees= poly_size=100 box_sides='1 1' ".
    "min_good='1' save_exprs='1 2 3' var_names='Blue_land Green_land
Red_land' ".
    "var_units= var_types='float float float' scale_offsets= scale_factors=
".
    "reflec_assem_$pid tmp_land_$pid") == 0 or die "Problem with emathp:
$!";

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system ("emathp expr_vars='Red_land' num_exprs=1 ".
    "y1_expr='land ? x1 : $min_red_scl' ".
    "use_degrees= poly_size=100 box_sides='1 1' ".
    "min_good='1' save_exprs='1' var_names='Red_land' ".
    "var_units= var_types='float' scale_offsets= scale_factors= ".
    "tmp_land_$pid tmp_land_red_$pid") == 0 or die "Problem with emathp:
$!";

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```

system ("copyvar include_vars='Red_land' overwrite_vars=yes ".
    "tmp_land_red_$pid tmp_land_$pid") == 0 or die "Problem with copyvar:
$!";

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system ("imscale include_vars='Blue_land' image_colors=250 bg_color=250
bad_color=0 ".
    "over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
    "zoom_factor=1 real_resample=no est_range=no min_value=$min_blue_scl
max_value=$max_blue_scl invert_scale=no ".
    "north_up=yes tmp_land_$pid tmp_landblue_$pid") == 0 or die
    "Problem occurred during imscale of blue land-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Blue_land image_colors=250
color_palette=black-white ".
    "draw_indexes= draw_names= tmp_landblue_$pid blue_land.tiff_$pid") == 0
or die
    "Problem occurred during expim of blue_land.tiff_$pid creation: $!";

```

```

system ("imscale include_vars='Green_land' image_colors=250 bg_color=250
bad_color= ".
    "over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
    "zoom_factor=1 real_resample=no est_range=no min_value=$min_green_scl
max_value=$max_green_scl invert_scale=no ".
    "north_up=yes tmp_land_$pid tmp_landgreen_$pid") == 0 or die
    "Problem occurred during imscale of green land-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Green_land image_colors=250
color_palette=black-white ".

```

```

"draw_indexes= draw_names= tmp_landgreen_$pid green_land.tiff_$pid") ==
0 or die
"Problem occurred during expim of green_land.tiff_$pid creation: $!";

system ("imscale include_vars='Red_land' image_colors=250 bg_color=250
bad_color= ".
"over_color=249 under_color=0 max_width=$SAMPLES max_height=$LINES
fixed_size=yes ".
"zoom_factor=1 real_resample=no est_range=no min_value=$min_red_scl
max_value=$max_red_scl invert_scale=no ".
"north_up=yes tmp_land_$pid tmp_landred_$pid") == 0 or die
"Problem occurred during imscale of red land-component of dust
enhancement: $!";
system ("expim image_format=tiff image_var=Red_land image_colors=250
color_palette=black-white ".
"draw_indexes= draw_names= tmp_landred_$pid red_land.tiff_$pid") == 0 or
die
"Problem occurred during expim of red_land.tiff_$pid creation: $!";

###
# Make RGB image
###
system ("tifftopnm red_land.tiff_$pid > red_land.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";
system ("tifftopnm green_land.tiff_$pid > green_land.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";
system ("tifftopnm blue_land.tiff_$pid > blue_land.ppm_$pid") == 0 or die
"Problem with tifftopnm call: $!";
system ("ppmtopgm red_land.ppm_$pid > red_land.pgm_$pid") == 0 or die "Problem
with ppmtopgm call: $!";
system ("ppmtopgm green_land.ppm_$pid > green_land.pgm_$pid") == 0 or die
"Problem with ppmtopgm call: $!";
system ("ppmtopgm blue_land.ppm_$pid > blue_land.pgm_$pid") == 0 or die
"Problem with ppmtopgm call: $!";
system ("rgb3toppm red_land.pgm_$pid green_land.pgm_$pid blue_land.pgm_$pid >
tmp_land.ppm_$pid") == 0
or die "Problem with rgb3toppm call: $!";
system ("convert ppm:tmp_land.ppm_$pid tiff:tmp_land.tiff_$pid") == 0
or die "Problem occurred during convert of modis dust enhancement
product: $!";

# Merge Ocean and Land RGB imagery, and metafile image
system ("imgmerge background_file=tmp_ocean.tiff_$pid
foreground_file=tmp_land.tiff_$pid clear_color=black ".
"output_format=tiff ${OUTNAME}.dust_tmp.tiff_$pid") == 0 or die "Problem
with imgmerge: $!";

system ("legend line_1=\"${satname}-MODIS $mm/$dd/$yyyy ${hhmm}-Z 1km Dust NRL
Monterey\" ".
"line_2=\"Pink=Possible Dust, Black/White=${min_sunlint}-Degree
Sunlint Zone\" line_3= text_height=$TEXT_HEIGHT text_type=bold line_offset=0
sample_offset=0 ".
"full_width=no center_text=no outline=yes solid_bg=yes $MASTER $LEGEND")
== 0
or die "Problem with legend: $!";

system ("xinject bg_var_name='master' colors_per=2 meta_colors='5 0 3 0 5 4' ".

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"line_widths='2 1 2' line_types= marker_types= marker_sizes= ".
"image_colors=4 $MASTER $GRID $COAST $LEGEND meta.tdf_$pid") == 0
or die "Problem with xinject: $!";

system ("expim image_format=tiff image_var=master image_colors=4 ".
"color_palette=black-white draw_indexes=\"3 4 5 6\" ".
"draw_names=\"violet white blue salmon\" meta.tdf_$pid meta.tiff_$pid")
== 0

or die "Problem with expim: $!";

print "Merging composite with meta image...\n";
system ("imgmerge background_file=${OUTNAME}.dust_tmp.tiff_$pid
foreground_file=meta.tiff_$pid clear_color=black ".
"output_format=tiff ${OUTNAME}.dust1KM.${SECTOR}.x.tiff_$pid") == 0 or die
"Problem with imgmerge: $!";

# Adjust image quality
system ("convert -quality 80 tiff:${OUTNAME}.dust1KM.${SECTOR}.x.tiff_$pid ".
"jpeg:${OUTNAME}.dust1KM.${SECTOR}.x.jpg_$pid") == 0
or die "Problem occurred during convert of modis dust enhancement
product: $!";

```